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THE CURRICULUM OF MATHEMATICS IN SECONDARY SCHOOLS.

By G. W. Evans.

The high-school subjects in mathematics are algebra and plane geometry. Changes in content or in method, if any, should be made for purposes that may be enumerated as follows: first, to secure more perfect continuity with the elementary school work; second, to prepare more perfectly for comprehension of mathematical science in general; third, to secure the pupil's spontaneous interest by giving him as wide command as possible of such utilitarian problems as are likely to enlist his ambition.

No fundamental change should be attempted, at least until the enterprising and well-informed teachers of the country are united in advocating it. Only two or three changes are suggested here, and if they seem fundamental, they should be taken rather as hopeful prophecy than as militant evangel.

For the first purpose, to promote continuity with elementary school work, more emphasis could be placed on numerical manipulation. Grant that computation is not mathematics, that a wonderfully facile computer may be a mathematical idiot; it is nevertheless true that the pupil feels less like a lost soul if he can hitch the new star to his old wagon. There is a feeling of security if these general quantitative truths can be actually reduced to numerical statement for particular cases.

This work in computation will likewise increase the pupil's practical command. Nothing in American public school education is quite so narrow as elementary arithmetic, confined, as it mostly is, to counting-room details. Decimals that are not dimes or coppers are very unusual. Let us say that a pupil should carry away from his high school work the ability to compute the capacity of his own coal-bin. If you think he can do it on entering the high school, try it. Give him dimensions to the nearest half-inch, and the weight of coal per cubic foot to hundredths of a pound. He is as likely to fill it with a shipload as with a cartload. It is our business to teach him in the first place to use his common sense as a check on his figures, and in the second place to limit the work of computation and the pretended accuracy of the result by the degree of accuracy of the data.

A further step for the same purpose could be such a change in the order of topics as making the rectangle-area one of the beginnings in geometry. This is one of the very few facts in geometry which the pupil brings with him from the elementary school. He knows it. As a general thing, he knows no reason for it, and yet it furnishes the most available illustration of fractional multiplication, and has a cogent proof that can be unfolded as he progresses. He is mystified rather than helped by the usual pedantic approach to this remnant of his childhood's knowledge.

Moreover this theorem can be used as a foundation for the similarity theorems, as well as for the whole subject of mensuration; so used, it will help to unify a subject which, Euclid's worshippers notwithstanding, does seem, to a beginner, heterogeneous.

As an example of the sort of change that may prepare for the better comprehension of mathematical science in the later work of the pupil, consider the demand made by many for the introduction of the idea of function into high school mathematics. So general a concept will be baffling, if stated as college students have it. But it can be approached through the study of formulæ. Not only formulæ such as mechanics and engineering use, but the treatment of every equation (with more than one letter) as a formula, explicit or implicit. Thus in eliminating by substitution, the pupil obtains an explicit formula for either letter from one equation and substitutes the formula for the letter in the other. This additional technicality has been found in practice to simplify teaching. With the moderate use of graphical methods, and with the introduction of natural trigonometric functions for computing geometrical relations in the triangle and the circle, the progress from formula to function will be gradual and not unnatural. Moreover the practice in algebraic manipulation may be made to appear as a study of different types of formulæ or of algebraic functions. Here again is an advantage in unity; elementary algebra will then appear first as a study of equations, considered as instruments for exact inference, and then as a study of different types of formulæ, or algebraic functions, some of which have been used for the treatment of equations, and others are studied as new types for their own sake, or for further use in which the pupil is expected to have faith.

The purpose which I have named last, that of securing keener interest on the part of the pupil, seems to me more important than the other two. Sneers at easy ways, and at attempts to amuse, cannot becloud the memories of your own youth; if you worked hard it was not because you were hammered into it, but because you found interest in subjects that repelled others not less able than yourselves. Many that failed could have succeeded; no searcher of statistics can find out what the world has lost by their rejection of mathematics.

One suggestion in the direction of this third purpose is to broaden the treatment of mensuration. Polygons and circles are the only plane areas a high-school graduate can measure; as for solids, he would have to ask a man with lime in his whiskers to estimate a retaining wall for him. Two ideas, mostly new to high school work, may serve to help this need. One is Cavalieri's theorem, embodied in the N. E. A. geometry syllabus; the other is Simpson's rule, familiar for generations to practical men and contemptuously ignored by school-teachers.

Cavalieri's theorem has a proof quite as easy to comprehend as that for the evaluation of π; and it can be so introduced into solid mensuration as to be a foundation for a good deal of the complicated formula-work, and to unify in a very great degree a subject that much needs it.

Simpson's rule is, to be sure, an approximation. It is a good approximation, however, and this fact has a good proof; and the proof of the value of a formula of approximation should not be without interest—even mathematical interest. Moreover it is applicable to solids; the formulæ for the volumes of pyramids and frusta—of the sphere also—being special cases of it. When we use it for solids it is the prismatoid formula, no longer approximate for the solids familiar to high school geometry.

Another, perhaps the greatest, advantage of this rule is the way in which it increases the pupil's command over plane areas. Amateur boat designers can use it to compute their body plans and deck and water line areas, to locate their center of buoyancy and their center of lateral resistance, to attack the question of stability, and so on. In one book on ship design that I have seen some of the formulæ for these purposes are exhibited with the notation of definite integrals, and are evaluated by Simpson's rule. It may be the beginning of John Perry's millenium, when every boy of fourteen will have some practical facility in the calculus.

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